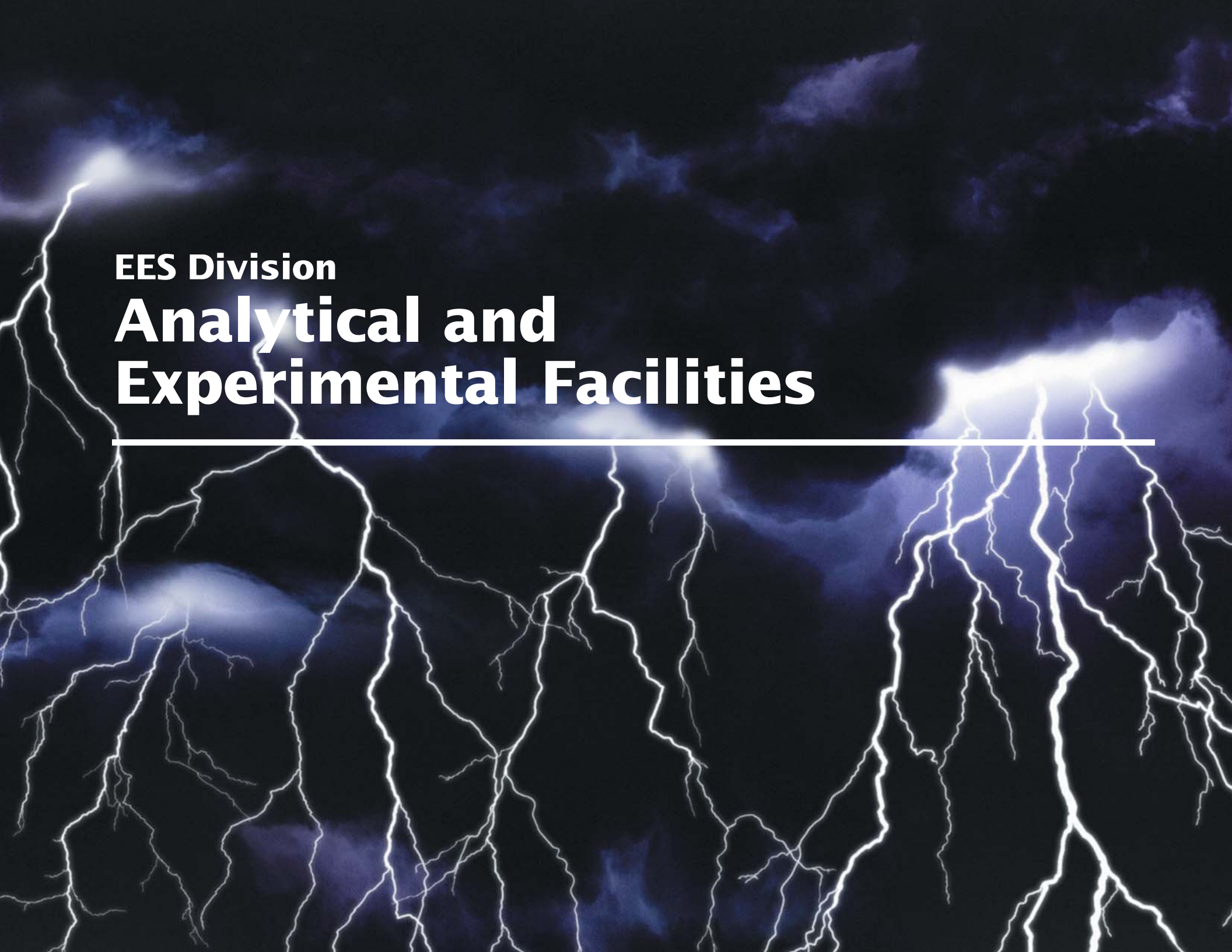

EES Division

# Analytical and Experimental Facilities

## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| **ADSR** | Associate Director for Strategic Research |
| **ARCS** | Atmospheric Radiation and Cloud Station |
| **ARM** | Atmospheric Radiation Monitoring Program (DOE) |
| **CAA** | contaminant analysis automation |
| **CBFO** | Carlsbad Field Office (DOE) |
| **CBO** | Carlsbad Operations (EES-12) |
| **CEMRC** | Carlsbad Environmental Monitoring and Research Laboratory |
| **DSSL** | Dynamic Stress Stimulation Laboratory |
| **EC** | environmental chemistry |
| **EES** | Earth and Environmental Sciences Division |
| **EES-2** | Atmospheric, Climate, and Environmental Dynamics Group |
| **EES-6** | Hydrology, Geochemistry, and Geology Group |
| **EES-7** | Geotechnical Engineering Research Group |
| **EES-9** | Environmental Geology and Risk Analysis Group |
| **EES-12** | Carlsbad Operations |
| **EPA** | Environmental Protection Agency (US) |
| **GGRL** | Geochemistry and Geomaterials Research Laboratory |
| **GIS** | Geographic Information System |
| **GISLab** | Geographic Information System Laboratory |
| **GPS** | Global Positioning System |
| **HEPA** | high-efficiency particulate air |
| **HIGRAD** | High-Gradient Applications Model |
| **LGL** | Luminescence Geochronology Laboratory |
| **LIDAR** | light detection and ranging (optical equivalent of radar) |
| **MBL** | mobile bioassay laboratory |
| **MOPO** | master oscillator power oscillator |
| **NMSU** | New Mexico State University (Las Cruces) |
| **QAP** | Quality Assurance Plan |
| **RC** | radiochemistry |
| **SDE** | Software Development Environment |
| **TRU** | transuranic |
| **TWPP** | Tropical Western Pacific Program |
| **UCSB** | University of California at Santa Barbara |
| **UFA** | unsaturated-saturated flow apparatus |
| **UV-Vis** | ultraviolet-visible (absorption spectrum) |
| **WIPP** | Waste Isolation Pilot Plant |
| **YMP** | Yucca Mountain Project |

# Overview of EES Division's Physical Plant Conditions and Analytical and Experimental Research Facilities

**Dorothy Austin,** EES-DO dot@lanl.gov

## SPACE AND INFRASTRUCTURE ASSESSMENT

In 2001 and 2002, the Earth and Environmental Sciences Division (EES) confronted several physical plant issues concerning aging facilities for which programmatic funding is not available, a long-standing concern that is integral to maintaining the division's infrastructures.

About half of the division's 330 members are situated in trailers and other transportable temporary structures that are costly to maintain and difficult and expensive to upgrade. The other half are located in a variety of permanent structures ranging from a warehouse to the open cubicle environment of the Otowi Building or to the 50-year-old Physics Building basement. None of the Los Alamos-based groups is located entirely in one location, and many teams likewise have their members scattered throughout the division's facilities. Significantly, EES does not own its own analytical and experimental research facilities and laboratories, but rather is a tenant in the structures it occupies. Of the 100,659 sq. ft. occupied by the entire division, only 56,412 sq. ft. are usable.

These circumstances have led to a search for third-party financing for the construction of up to four new permanent buildings that the division will own. We are seeking this funding through our Associate Director for Strategic Research (ADSR) Office.

*Fig. 1. Los Alamos mesa and canyon view, looking eastward.*

EES Division prepared a model Facility Strategic Plan that ADSR will use in obtaining the building funds essential to the division. The plan is part of the Ten-Year Comprehensive Site Plan for general construction at Los Alamos. EES ranks among the top five organizations that are awaiting funding for infrastructure and construction. We are very fortunate to have the support of one of the champions of third-party financing, Directorate Operations Manager Christopher Webster, who has helped position the division high on the facilities new-construction list.

## The Research Laboratories

The following analytical and experimental research laboratories are operated programmatically by EES or by EES programs.

The Tropical Western Pacific Program (TWPP) operates and monitors instruments at the **Atmospheric Radiation and Cloud Station (ARCS)** to develop and test parameterizations of important atmospheric processes, particularly clouds and radiative fluxes in the atmosphere. An essential data-gathering source for DOE's Atmospheric Radiation Monitoring Program (ARM), ARCS was created over a decade ago under the US Global Change Research Program. ARM provides data essential to climate research and weather prediction.

EES-2 Group's TWPP Team operates climate stations for ARM at four sites in the equatorial western Pacific: the Papua New Guinea mainland; Manus Island, off Papua New Guinea; Nauru, a small island republic south of the Marshall Islands; and Darwin, Australia. The objective of the program is to produce measurements suitable for testing parameters in a variety of situations that is sufficiently wide to span the range of climatologically relevant possibilities.

**The Dynamic Stress Stimulation Laboratory (DSSL)** for Enhanced Porous Fluid Flow Studies is a unique laboratory designed to study the effects of low-frequency stress waves on permeability and multiphase fluid flow in rock core samples. Understanding this phenomenon will lead to improved technologies for enhancing oil production and groundwater remediation. Experiments are conducted using a range of different formation rock types as well as composite samples with varying initial permeability versus axial position. The specialized computing equipment and software allow for testing a large number of initial conditions and stimulation parameters in a short period of time.

EES-2 Group's **Ecological Greenhouse** is the location for experiments on the growth and survival of nonnative and native plants in marginal soils, as well as studies of nutrient flow between plants and soils. These efforts are collaborations between the EES and Bioscience divisions. The greenhouse also contains a growth chamber for small-scale experiments that require control of light, temperature, and humidity. Future studies include research into the dynamics of the rapid vegetation shifts that are being observed today throughout the world in response to drought, climate change, and other disturbances such as fire.

*Fig. 2. Los Alamos mesa and canyon view, looking northward.*

**Infrasound Calibration Laboratory.** Los Alamos' acoustic-infrasonic capabilities extend to frequencies as low as 0.02 Hz (equivalent to a wavelength of approximately 10 miles at room temperature). This capability is part of the Infrasound Calibration Laboratory, a component of DOE's Ground-Based Nuclear Explosion Monitoring Program.

EES-2 Group's infrasound research includes applications for studying low-frequency sound propagation in the Earth's atmosphere and modeling of low-frequency source processes based on standard hydrodynamic theory. From this research, we can develop expressions for the behavior of pressure and wave frequency and use them to model or examine how the source affects the atmosphere, enabling understanding of atmospheric behavior from great distances.

EES-6 Group's **Geochemistry and Geomaterials Research Laboratory (GGRL)** houses analytical instruments and experimental facilities for understanding Earth materials and Earth systems. GGRL houses a wet chemistry laboratory, x-ray diffraction laboratory, thermal analysis capabilities, optical equipment, a light-stable isotope laboratory, electron microanalysis, an x-ray fluorescence laboratory, and laser ablation mass spectrometry for trace element analysis. Applications include groundwater chemistry, minerology, petrology, and extraction and mineralization of atmospheric carbon dioxide.

EES-9 Group's **Geographical Information Systems Laboratory (GISLab)** brings to bear on research topics more than 60 combined years of high-level GIS expertise and the Laboratory's most sophisticated GIS technology for cutting-edge 3-D modeling and visualization, and the ability to rapidly develop and support custom GIS applications. Research and development focuses on environmental applications of GIS and spatial decision-support systems. GISLab offers a full suite of GIS services and consultation in support of Laboratory projects and operations including cartography (hard copy and Internet), data service through Software Development Environment and Oracle, custom GIS applications, GPS mapping, spatial and numerical modeling, Internet GIS, and consultation on spatial information management and GIS technology. Over the years, GISLab has produced more than 11,000 original maps and more than 30,000 map copies for customers within and outside of Los Alamos National Laboratory.

The **Luminescence Geochronology Laboratory (LGL)** houses equipment that is used to date geologic materials and to help us understand natural processes and their rates of evolution. EES-2 Group's LGL Team studies environmental problems relating to DOE laboratory operations as well as to more fundamental problems related to the Earth's surface processes. LGL houses specialized equipment for luminescence dating and retrospective dosimetry and for determining beta-dose rate from soil in support of luminescence dating. It also has an instrument for in situ field assessment of beta and gamma dose rate, which also supports luminescence-dating research.

The **Los Alamos Seismic Network Station** aids in seismic verification research and monitors earthquakes.

**LIDAR Laboratory and Field Equipment.** Small-scale atmospheric imaging laser applications have a long history at Los Alamos. One of the more innovative of these applications is a mobile scanning Raman LIDAR system. Used in combination with the simulation capabilities of HIGRAD (High-Gradient Application Model, an EES computational tool), the Raman LIDAR measurements present an extremely powerful tool for understanding the behavior of the atmospheric surface layer and its interactions with underlying vegetation or other surface characteristics.

## Nuclear Waste Facilities

In addition to providing analytical and experimental facilities, EES Division plays a major role in the Waste Isolation Pilot Plant (WIPP) and in the underground experimental facilities at the Yucca Mountain Project, a potential high-level waste repository. Brief descriptions of these facilities follow.

**Waste Isolation Pilot Plant.** EES-12 provides project management for the WIPP site. It also provides a senior technologist team for the development of standardized characterization capabilities for waste characterization, certification, mobile system support, and waste fingerprinting at all 27 DOE transuranic (TRU) waste sites. The EES-12 Group's unique role at WIPP and the transuranic waste sites is based on demonstrated direct experience and expertise in waste characterization, certification, and physical waste handling and loading. EES-12 focuses on four key areas of research: acceptable knowledge and inventory; TRU waste characterization technologies; waste optimization and acceleration; and mobile loading and modular systems design.

**Yucca Mountain Project Site.** In July 2002, at DOE's recommendation, the US Congress agreed to accept a license application for the Yucca Mountain Project (YMP), the nation's first long-term geologic repository for spent nuclear fuel and high-level radioactive waste. This breakthrough was the culmination of 24 years of scientific studies, much of which was headed by Los Alamos researchers. EES-7 Group's Test Coordination Office Team, located at the YMP site, is responsible for planning and coordinating all field and laboratory tests. The work is conducted under a fully qualified DOE quality-assurance program and a management and oversight safety and health plan following the principles of Integrated Safety Management.

The major tests and facilities at the YMP site include the Exploratory Studies Facility, the Drift-Scale Test, enhanced characterization of the repository block, surfaced-based drilling and coring operations, and the Underground Transport Test Facility. ■

# Actinide Chemistry and Repository Science Program Capabilities at Los Alamos' Carlsbad Operations and CEMRC

**Jim Conca** EES-12 jconca@lanl.gov

## INTRODUCTION

DOE'S Carlsbad Field Office (CBFO) currently operates the Waste Isolation Pilot Plant (WIPP) near Carlsbad, NM, as a repository site for transuranic (TRU) waste generated as part of the nuclear defense research and production activities of the federal government. To address near- and long-term scientific and technical issues pertaining to the certification and operation of the repository, CBFO created the Actinide Chemistry and Repository Science Program with Los Alamos National Laboratory as the lead laboratory. Los Alamos has formed a scientific partnership with the Carlsbad Environmental Monitoring and Research Laboratory (CEMRC) that will allow for a collaborative implementation of the Actinide Chemistry and Repository Science Program, taking advantage of CEMRC's existing resources in staff, facilities, and equipment augmented by new Laboratory equipment and staff. This collaborative effort began in April 2001 and is supported directly by DOE and contractually between the Laboratory and CEMRC (Fig. 1).

The Laboratory's Carlsbad Operations (CBO), also known as EES-12, was formed (1) to provide technical and programmatic support to the CBFO, (2) to further develop plans and processes to improve efficiencies related to TRU waste management and disposal, (3) to address scientific issues in actinide chemistry and repository science as they arise, particularly if they impact certification and performance, and (4) to serve as the acceptable knowledge expert focused on certifying TRU waste from the DOE complex small-quantity sites and other large-quantity sites.

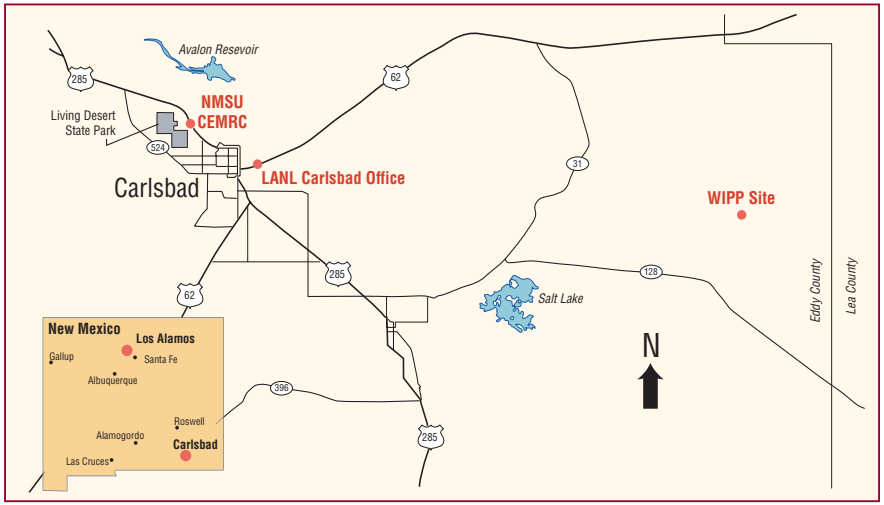


*Fig. 1. Locations of Los Alamos and CERMC facilities and the WIPP site.*

CERMC is a division of New Mexico State University's (NMSU) College of Engineering. CEMRC was established with a grant from DOE to NMSU for construction and operation of the 26,000-sq.-ft. building with environmental and radiochemistry laboratories, in-vivo bioassay facility, mobile bioassay laboratory (MBL), computing operations, and offices. Construction of this facility was completed in December 1996.

## Capabilities

The primary focus of the Radiochemistry (RC) Group at CEMRC is the measurement of radioactive substances in various media. These media include but are not limited to aerosols, soil, surface water and sediment, groundwater, drinking water, biota, and bioassay. Approximately 1,700 sq. ft., including a primary radiochemistry laboratory, and sepa-

rate tracer and counting laboratories, are allocated to the Radiochemistry Program. The primary laboratory room is equipped with one 6-ft. perchloric acid hood, five 8-ft. chemical hoods, a separate deionized water system, refrigerator, centrifuge, and about 400 sq. ft. of bench surface. The instrumentation laboratory is equipped for low-level measurements of actinides, fission products, activated corrosion products, and naturally occurring radionuclides, and has the lowest detection limits possible for many elements. This instrumentation includes 72 alpha spectrometers, two germanium gamma-ray spectrometers, two well-geometry (germanium) gamma-ray spectrometers, five gas proportional counters, and a liquid scintillation counter.

In addition, the RC Group currently participates in the DOE Environmental Measurements Laboratory Quality Assessment Program and is a participant in the National Institute of Standards in Technology's Radiochemistry Intercomparison Program for evaluation of low-level radionuclide measurements. Recent modification to the license allows for work of up to 2 Ci. New infrastructure will allow for work at these higher levels.

All work is performed in accordance with the requirements of the quality-assurance plan (QAP) for the RC Group. The QAP describes laboratory activities related to quality-assurance objectives for measurement data; sample custody; calibration procedures and frequency; analytical procedures; data reduction, validation and reporting; internal quality-control checks; calculation of data; and quality indicators.

The primary focus of the Environmental Chemistry (EC) Group is the measurement of inorganic substances, including aerosols, soil, surface water and sediment, groundwater and drinking water, biota, and bioassay, in various media at environmental background levels. Approximately 1,400 sq. ft. of laboratory space is allocated to environmental chemistry, including a primary laboratory for sample preparation and an instrumental analysis laboratory. The primary laboratory room is equipped with three 8-ft. chemical hoods, ultrapure water system, two microwave digestion units (Milestone Ethos and a CEM MDS2100), a reagent distillation and purification system, a dishwasher and refrigerator, electronic balance, and approximately 170 sq. ft. of bench surface. Of the bench surface, approximately 40 sq. ft. are clean benches, which protects samples and reagents from contamination by acids and particulates. The instrumentation laboratory is equipped for the analysis of trace elements, including heavy metals. This instrumentation includes a Perkin-Elmer 5100 PC atomic absorption spectrometer with flame and graphite furnace, a low-resolution inductively coupled plasma mass spectrometer (ICP-MS, Perkin Elmer Elan 6000), and an ion chromatograph (Dionex 500). In addition, the EC Group participates in the InterLaB WatRTM Pollution WP-58 Proficiency Testing Program managed by Environmental Resource Associates, and is accredited for environmental testing through the American Association of Laboratory Accreditation.

*Fig. 2. Aerial view of the WIPP facility.*

CEMRC's in vivo Bioassay Facility occupies about 1,000 sq. ft. and provides the primary analytical infrastructure for the internal dosimetry program. The facility includes a large shielded counting chamber, dedicated instrument control workstation, two change rooms with showers and toilets, and a reception area. The counting chamber measures 8 cu. ft. and is constructed of 10-in.-thick cast iron. The counting chamber is equipped with a lung and whole body counting system consisting of eight germanium detectors. Ultrasound techniques are used to measure the subjects' chest wall thickness and composition to account for photon attenuation caused by positive lung burdens. The program is accredited by DOE's Laboratory Accreditation Program for Radiobioassay.

The MBL is a unique component of the Center's facilities. The MBL was designed to provide advanced bioassay and environmental analyses for on-site support of emergency and incident response, decommissioning, environmental restoration, and other research activities. Fabricated from a reinforced 57-ft. trailer, the MBL is transportable by highway. Special electrical and HVAC systems provide adequate support for electronics and environmental control. Self-contained potable water supply and gray-water

waste tanks are also provided. Approximately 190 sq. ft. of the trailer—half of its area—is dedicated to analytical chemistry and has been modified to accommodate actinide chemistry studies.

As a result of the partnership between Los Alamos and CEMRC, other state-of-the-art capabilities have recently been installed at CEMRC:

- A Nd:YAG master oscillator power oscillator (MOPO) laser system combining photoacoustic, fluorescence, and breakdown spectroscopy.
- An x–ray diffractometer using Bragg-Brentano or parallel-beam geometry (Göbel mirrors) combined with phase quantification by Rietveld and least-squares refinements, and with phase constitution analyzed to temperatures and pressures up to 600°C and 1 Mpa.
- An unsaturated-saturated flow apparatus (UFA), ASTM D6527, that can directly measure all transport properties (K, D, ψ, G, and others) in porous media (rock, cement, ceramic, soil, and others).
- A state-of-the-art Cary 550 UV–Vis spectrophotometer with temperature control, multisample capabilities, and less than 0.1-nm resolution.

Los Alamos relocated the Contaminant Analysis Automation (CAA) Mobile Environmental Laboratory at CEMRC (see Fig. 3) and integrated it into the facility in order to perform higher activity-level experiments, particularly for plutonium, and to provide necessary flexibility and containment outside of the main laboratories. The CAA includes glove boxes, ductless high-efficiency particulate air (HEPA) filtration hoods, soxhlet extractors, digestors, and gas chromatography and mass spectrometry.

*Fig. 3. Mobile Environmental Laboratory.*

## Initial Research Focus

As a functioning deep geologic repository for nuclear waste, the Waste Isolation Pilot Plant (WIPP) requires an experimental program to address specific scientific and technical issues related to waste characterization, repository performance, enhanced operations, and the five-year recertification cycle mandated by Title 40CFR194. The 40CFR194 standard also provides for modification of certification. Modifications may be driven by additional planned or unplanned changes to the technical basis originally certified by the US Environmental Protection Agency (EPA). Many under consideration by the CBFO will require technical underpinning that may include both radiological and stable-element chemistry experimentation. In addition, it is also possible that near-term studies could be needed of the effects of radiolysis on the oxidation state and speciation of plutonium, effects of organic ligands on the solubility of plutonium in WIPP-relevant brines, and effects of waste form characteristics in determining the solubility of plutonium.

TRU waste is contaminated with alpha-emitting radionuclides that are heavier than uranium and that have half-lives longer than 20 years at concentrations greater than 100 nanoCi per gram of waste. Important radionuclides found in TRU waste include americium-241 and several isotopes of plutonium (plutonium -238, -239, -240, and -241). Throughout the DOE complex, several types of operations (past, current, or future), including nuclear weapons production; plutonium recovery, stabilization, and management; research and development; environmental restoration, and decontamination and decommissioning; and waste management and testing at facilities that are under DOE contract, have generated or will generate TRU waste. DOE is responsible for the management and ultimate disposition of TRU waste generated at DOE sites and, as directed by Congress, has constructed WIPP for the purpose of disposing of TRU waste resulting from defense activities. Within DOE, the WIPP facility is managed under the Office of Environmental Management, which has the principal mission of remediating environmental sites at DOE facilities and disposing of radioactive waste. The WIPP storage area is located in bedded salt at a depth of 650 m, at a site approximately 30 miles east of Carlsbad.

The activities that can be performed in the laboratories at CEMRC and CBO can be generally described as directed research and development in actinide chemistry involving low levels of radioactive materials (up to 2 Ci). The activities involve reactions in the solid state and in

aqueous and nonaqueous liquid media, which vary with programmatic requirements. No production or process lines or routine waste treatment operations are carried out in the facility. This is a multiuser facility in which long-term and short-term projects can be carried out as defined in the associated hazard control plans.

The laboratories focus on special nuclear material (specifically, plutonium-238, -239, -240, -241, and -242; neptunium-237; curium-244 and -248; and americium-241 and -243, in quantities that would never be sufficient to form critical mass); source material (for example, uranium and thorium series); and byproduct material (for example, technetium-99, yttrium-90, strontium-90, and cesium-137). All of the research activities are permitted under the existing broad-scope license possessed by CEMRC.

DOE is proposing to conduct several experimental studies of issues relevant to WIPP operations and EPA recertification at Los Alamos and CEMRC. These studies would help DOE address specific scientific and technical issues related to waste characterization, repository performance, and enhanced operation of the repository. Planned and potential experiments to support WIPP operations and recertification include, but are not necessarily limited to, (1) the effects of WIPP-relevant materials, such as reductants iron and aluminum, and potential radiolysis byproducts, such as hypochlorite and peroxide, on the oxidation states and speciation of plutonium; (2) the effects of organic ligands on the mobility of plutonium and other actinide elements in WIPP-relevant brines; (3) the demobilization of actinides by borehole fill materials; and (4) the efficacy of oxidation state analogs for predicting the behavior of the actinides. These studies would require the use of the radioactive isotopes of plutonium, americium, uranium, thorium, and neptunium, and, perhaps, cesium and strontium. Specific issues that may be addressed include the following, not necessarily listed in order of priority:

- The occurrence of plutonium (V) and plutonium (VI) in some of the Actinide Source-Term Waste Test Program experiments. (The Roman numerals designate oxidation states.)
- The effects of alpha radiolysis of WIPP-relevant brines on the oxidation states of plutonium, uranium, and neptunium.
- Reduction of oxidized actinides such as plutonium (V) and plutonium (VI) to plutonium (III) and plutonium (IV), respectively, by steel, other iron-base metals, and aluminum.
- The effects of actinides and, perhaps, other heavy metals, magnesium oxide, and other relevant materials, basic pH, and radiolysis on microbial activity.
- Possible microbial reduction of plutonium (V), plutonium (VI), uranium (VI), and neptunium (V).
- Effects of reactions between WIPP brines and various waste forms on brine chemistry, especially Eh and pH.
- An integrated thermodynamic and kinetic redox model for plutonium under expected WIPP conditions.
- Coprecipitation and sorption of plutonium, americium, uranium, thorium, and neptunium by magnesium oxide and other relevant materials such as cements.
- The extent to which colloids could increase the solubilities of plutonium, americium, uranium, thorium, and neptunium by forming complexes with these elements in WIPP brines.
- The extent to which organics could increase the solubilities of plutonium, americium, uranium, thorium, and neptunium.

DOE can also conduct two other categories of study at CBO and CEMRC: (1) experimental studies of issues relevant to the characterization of TRU waste; and (2) studies for possible funding by other DOE projects, other federal agencies, private American companies, or even foreign governments or companies. These studies could require the use of radioactive elements other than those listed previously. ■